IRISH FISHERIES INVESTIGATIONS

SERIES B (Marine)

No. 4

(1968)

AN ROINN TALMHAIOCHTA AGUS IASCAIGH
(Department of Agriculture and Fisheries)

FO-ROINN IASCAIGH (Fisheries Division)

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THE WHITING FISHERY OFF COUNTIES DUBLIN AND LOUTH ON THE EAST COAST OF IRELAND.

1. THE COMMERCIAL CATCH.

by

J. P. HILLIS

INTRODUCTION

The whiting *Merlangius merlangus* (L) has for over 30 years been the leading demersal species by weight in the landings of commercial fisheries on the east coast of Ireland. The present study was commenced in the autumn of 1959, using samples of both the commercial fishery and the research vessel Cú Feasa. The present paper describes the commercial catch from port samples supplemented with research vessel material where extra detail is desirable. Detailed description of the research vessel investigations, however, is a substantial topic in itself, and will be the subject of another paper. This paper also describes the place of the Irish Sea whiting fishery in the context of the world population of the species. For the wider ranging geographical and historical details, much use is made of the various publications of the International Council for the Exploration of the Sea (ICES). For most purposes, the material used extends up to the end of 1965.

The whiting in Europe.

The whiting is a gadiform fish inhabiting European Atlantic waters ranging from Norway and Iceland in the north to France in the south, the main centre of population being the North Sea. Fig. 1 gives the ICES statistical areas where the whiting occurs, the weight of its catch, and the principal other gadoid fish in the fishery.

The North Sea (ICES statistical area IV), yielded about half the species total catch from 1961 to 1963. There are important subsidiary populations in adjoining waters of similar latitudes, notably the Skagerrak and Kattegat (IIIa), Irish Sea (VIIa) and areas west of Scotland (VIa) and south of Ireland (VIIg, VIIj). Thus, over 90% of the world catch is taken between latitudes 48° and 61°N and longitudes 13°E and 12°W, though some may possibly come from deeper water further west. On the southern fringe, the English Channel and Bay of Biscay have small populations, and French statistics show some small returns from the Mediterranean Sea. Northwards, a rather isolated population exists in S.W. Icelandic waters (Va), from which the catch is small, though larger than that of Faroe (Vb), while east Greenland, north-west Norway, and the Baltic all return very small amounts. Of adult size much smaller than cod and coalfish (saithe) and slightly smaller than haddock, the whiting ranks after these three species and before hake in the size of its gross catch in the ICES area, though in parts of the North Sea, the English channel, Irish Sea, and inshore on all Irish coasts it yields the highest catch of all gadoids. It is exceeded by the hake, however, in the extreme south and south west.

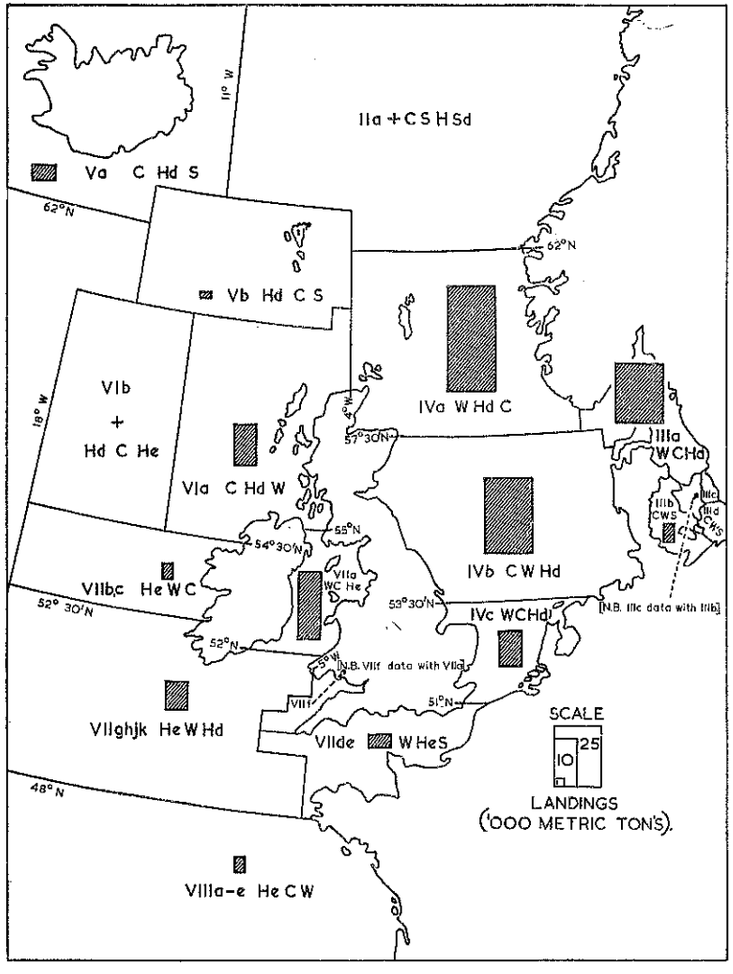

Fig. 1. Mean landings of whiting 1961-1963 by ICES statistical areas indicated by relative size of shaded rectangles. ICES statistical areas are designated, together with the three species of gadoid fish yielding the greatest landings in descending order, as follows:—
W = Whiting; C = Cod; Hd = Haddock; S = Saithe; He = Hake.

Irish Distribution.

Whiting are caught in five discrete areas round the Irish coast, east, south-east, south-west, west, and north-west, as shown in Fig. 2, the intervening coasts contributing a very small fraction of the catch—0.8% in 1963/1965. The present survey is concerned with the fishery in the Irish Sea, based on the east coast ports of Howth, Skerries, Balbriggan and Dún Laoghaire, County Dublin, and Clogherhead, County Louth. This fishery is to a considerable extent continuous with that operating from the County Down ports of Kilkeel, Ardglass and Portavogie, but the two areas of densest population and highest

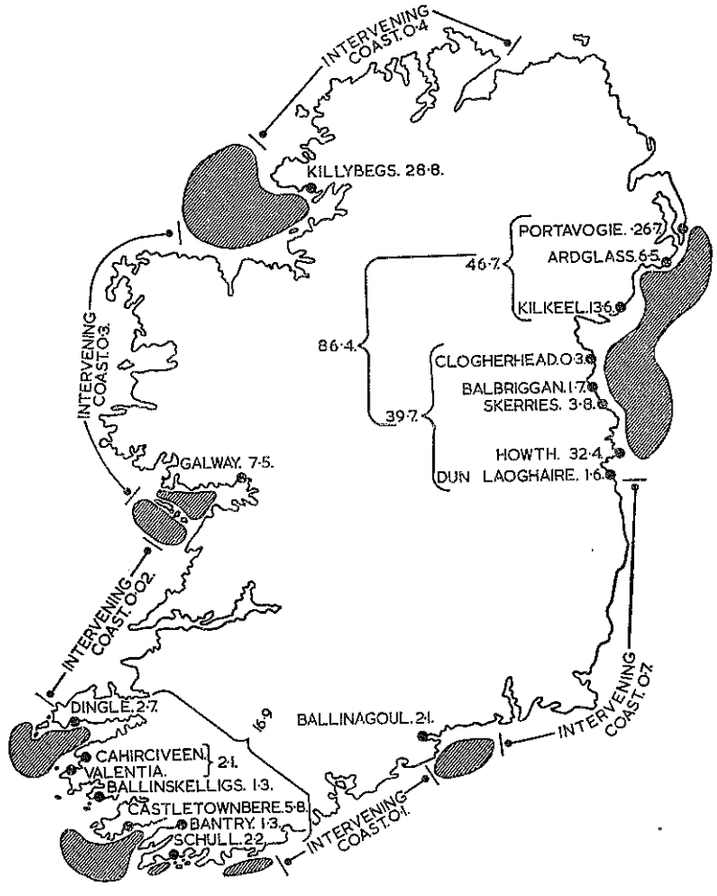

Fig. 2. Whiting fisheries of Ireland, showing areas of fishing grounds, hatched, and mean landings ('000 cwt) 1963-1965 at main ports. Mean landings for intervening areas of coast are also shown to demonstrate the extent to which the fishery is confined to discrete areas.

fishing intensity are well defined and far apart, being off County Dublin in the Lambay Island—Rockabill area, and off County Down in the outer part of Dundrum Bay. There is also a slight difference in age composition of the stocks, the most numerous age group in the County Down landings being 2 (Garrod & Gambell 1965, Fig. 4A, page 8) in contrast to County Dublin, where it is age-group 1.

The total combined area lies between latitudes 53°20'N and 54°30'N and between the 10 and 50 fm contours, which lie at about 6°00'W and 5°30'W in the southern area, but swing further east off County Down. Thus, of the statistical rectangles of ICES (*Statistical News Letter* 1965), it occupies b7 (except the extreme southeast) c6, the

eastern half of b6, the northern half of c5 and the north western quarter of b5. This is the most concentrated whiting fishery area in the Irish Sea, but it does have exchange of stock with others in the Irish Sea, and in the Clyde.

Previous work on Irish Sea whiting.

Literature on Irish Sea whiting is rather limited, in contrast to the long history of examination of North Sea stocks. A comparison of the Irish Sea whiting with those of the west of Ireland, as regards growth, food and sexual maturity, was made by Elkin (1955); findings concerning growth (Hillis, 1960, 1962b, 1963), meristic characters (Hillis, 1961) and mesh-selection (Hillis, 1962a) have appeared in recent years; and Garrod and Gambell (1965) have exhaustively discussed the fisheries of Great Britain and that off County Down so closely linked with that off Counties Dublin and Louth. Works covering special aspects of whiting biology in the Irish Sea include those by Bowers (1954) on breeding and growth, and Nagabushanam (1964), on the same topics but with special attention to young stages of the whiting.

History of the whiting fisheries of the Irish Sea.

Records from 1927 onwards show that the Irish Sea whiting fisheries have been worked by the Republic of Ireland, Northern Ireland, England and Wales, France, and to a small extent, Scotland and Belgium (Tables 1 and 2).

The catch in the Irish Sea Region VIIa of ICES) and the Irish catch per unit effort therein for the years 1927-1955 with the Scottish catch in the fishery districts comprising the Firth of Clyde for comparison are given in Table 1. Similar information but with more detail—including the English catch per unit effort—for the more recent years commencing 1956, is given in Table 2. The location of the main whiting fisheries in the Irish Sea and Clyde is shown in Fig. 3.

The east coast of Ireland—Counties Dublin, Louth and Down—fisheries occupy practically all the Irish effort on whiting based in the area (though Dublin boats occasionally fish off Anglesey, and Down boats may do so in the Firth of Clyde). A small proportion of the catch from this fishery—10.5%, 3.3% and 7.5% respectively in 1958, 1959 and 1960—was made by English boats.

Information regarding French effort in the Irish Sea is unavailable. Garrod and Gambell (1965) have outlined the changes in landings for England and Northern Ireland over the period 1927-1960, together with the Rpeublic of Ireland statistics for the east coast. They have also calculated catch per unit effort for England and the Republic of Ireland, no effort data being available for Northern Ireland. The general trend over the years is one of gradual increase in landings, together with a great temporary boom around the end of the 1939/45 war, when the peak years for landings were 1944/46 for the Republic

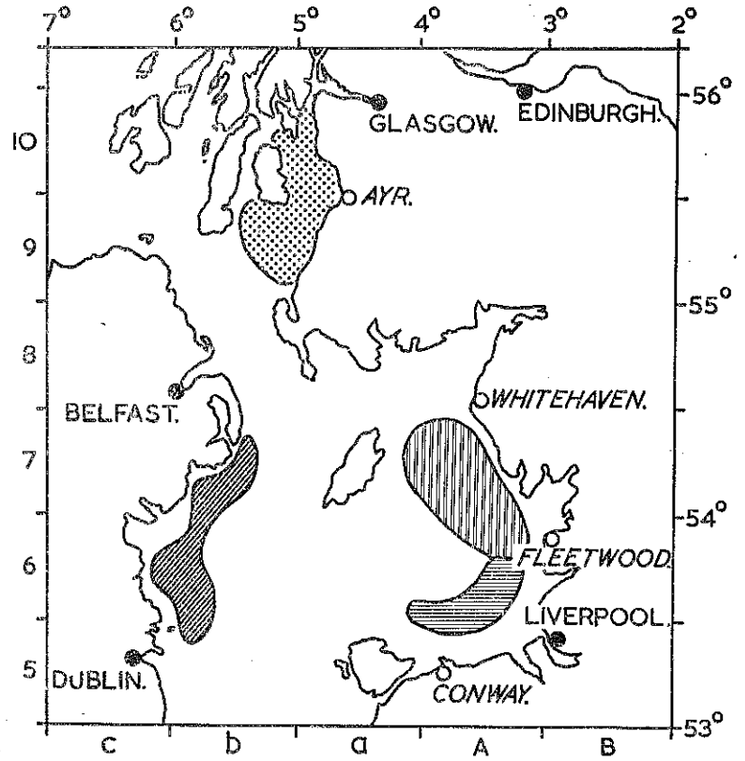

Fig. 3. The Irish Sea, showing the Counties Dublin and Down whiting fisheries and those of adjacent areas off the coasts of Great Britain.

of Ireland, 1945/48 for Northern Ireland and 1948/49 for England and Wales. In the case of England and Wales, however, the catch per unit effort had its peak in 1945/46 for steam trawlers and 1946/47 for motor trawlers, and was already falling considerably when much increased effort yielded the peak in landings of 1949. Garrod and Gambell state that the effort in County Down during the war years was increased by an influx of vessels from the east side of Scotland, so it is reasonable to attribute the increase of the late 1940's to one or more very strong year classes, the more youthful age composition of the County Dublin catch causing its peak to occur slightly earlier than that of County Down, which in turn came before that of England and Wales. Since 1950, short-term fluctuations in Irish catch/effort have tended to be matched about two years later by those in English data. The English catch per unit effort, however, fell very sharply in 1954/55, since when it had not shown its former strength relative to the Irish before 1960, when Garrod and Gambell's observations ceased, though it has done so in some years since, notably in 1962.

As regards landings, since 1950 those of England and Wales have shown a net decrease, falling to about their pre-war level; those of

Down have increased slightly and those of Dublin/Louth markedly. French landings for VIIa since 1958, their first year in any real quantity, increased sharply to become greater than all others combined in 1964 and 1965.

Relationships of the County Dublin Fishery with those in neighbouring areas.

In enumerating the different whiting fisheries of the Irish Sea, Garrod and Gambell (1965) have shown the great magnitude of the Dublin and Down fisheries compared with those elsewhere. Both have a strong peak in Autumn, and in recent years about March also, but as already noted they differ in age composition, that of Dublin being based on age-group 1 fish, while age-group 2 is more prominent in the Down fishery.

North of latitude 53°, the chief fisheries on the British side lie off the coasts of Cumberland, Lancashire and North Wales, in ICES satistical rectangles A7, A6, A5, and to some extent a5 (see Fig. 3). The main ports are Whitehaven, Fleetwood and Conway. In general, the Cumberland fishery is productive all the year round, that off Lancashire is similar but to some extent intermediate, and the Conway fishery is seasonal, operating mainly in Spring. The age composition in these fisheries is higher than on the Irish side, age-groups 2—4 being the most prominent.

Elsewhere, there is a small spring fishery for large whiting in St. George's Channel, and in the Firth of Clyde (where Ayr is the chief port) as in the Dublin area, an autumn fishery with a subsidiary peak about March for age-group 1 fish. A mean vertebral count of 53.38 was found for Clyde fish by Gamble (1960) as against 53.49 for the Dublin area (Hillis 1961).

In both the Dublin area and the Clyde there is evidence of a spawning migration towards the North Channel. Garrod and Gambell (1965) record whiting larvae as numerous off the Mull of Kintyre and the Antrim coast in May 1960 and 1961, and returns of fish tagged in the Clyde in November after 90—120 days liberty were almost exclusively from the lower and outer reaches of the Firth. In Ireland, spring landings increase progressively going northwards, reaching their peak at Portavogie (Fig. 4) and the percentage returned from the Down coast of fish tagged by British workers off County Dublin in late 1957 and 1958 was as follows:— December, 6%; January, 29%; February, 50%; March, 61%; April, 83% after which returns were much fewer and mainly from Co. Dublin, (Garrod, pers. com.). Of whiting tagged off Down at the same time, returns from County Dublin were always much fewer. Similar results were found in Irish tagging experiments during 1963-1965.

Whiting tagged in summer in the Clyde and off Cumberland and the Isle of Man which moved to the Irish grounds were mostly recaptured in the Down rather than the Dublin area. This is in keeping

with the older age composition of the County Down whiting. Fish tagged off Down or Dublin and recaptured in the autumn season the following year, however, were mostly recaptured in the area in which they were tagged.

Tag returns from outside the Irish Sea and Clyde areas have occurred from St. George's Channel and Devon and Cornwall to the south, and the Inner Hebrides area, to the north.

CATCH AND EFFORT

The landings of whiting at each port in each month are available since 1958, permitting the yield of the Dublin fishery, together with its Down counterpart, to be examined (Fig. 4). The effort expended to realise such catches, however, is only available, in limited detail, since 1961. These data are employed to give a reasonable assessment of catch (cwt.) per unit effort in Brake-Horse-Power-Days, or Standard Boat-days for Howth, the one port where whiting landings persisted at a high level throughout the period.

Trends in total catch.

The pattern of the Dublin whiting fishery from 1958 is shown in Table 3. It is mainly that of an autumn fishery, extending from August till January, with its peak landings in October or November, tending to occur slightly earlier off Dublin than Down. The poorest landings are in late spring and early summer, also slightly earlier in the south than the north. The Dublin landings exceed those of Down only in summer, when owing to the *Nephrops* and other fisheries whiting landings practically cease, during the early stages of the autumn boom, and January and February in the years 1960/62. Combined (Down and Dublin) landings for the peak months in 1958, 1959, 1961 and 1962 were roughly 35,000 to 50,000 cwt. The year 1960 was poor, especially for County Down. The Dublin landings in that year, whilst below average, remained higher than those of Down in November, the peak month, (when the combined total was only 19,000 cwt.) and December. In 1963 and subsequent years, the combined landings for the peak autumn month have not exceeded 12,000 cwt, and a much increased proportion has been landed in County Dublin.

The overall decline in autumn landings since 1958 has been accompanied by the rise of a spring peak—much more marked in Down than Dublin. In 1958 a very slight rise took place from March to April. In 1960 and 1961 the rise in Down landings more than offset the fall in those of County Dublin from February to March, when the combined total rose from 3,200 to 4,100 cwt in 1960 and from 4,100 to 5,400 cwt in 1961. In 1962, March landings were nearly treble those of February—the increase being mainly in Down—and they rose slightly in April, falling sharply again in May. The pattern in 1963, 1964 and 1965 has been similar but the increase from March to April has been greater, and in the area as a whole though not the Dublin part, the April landings have exceeded those of any autumn month.

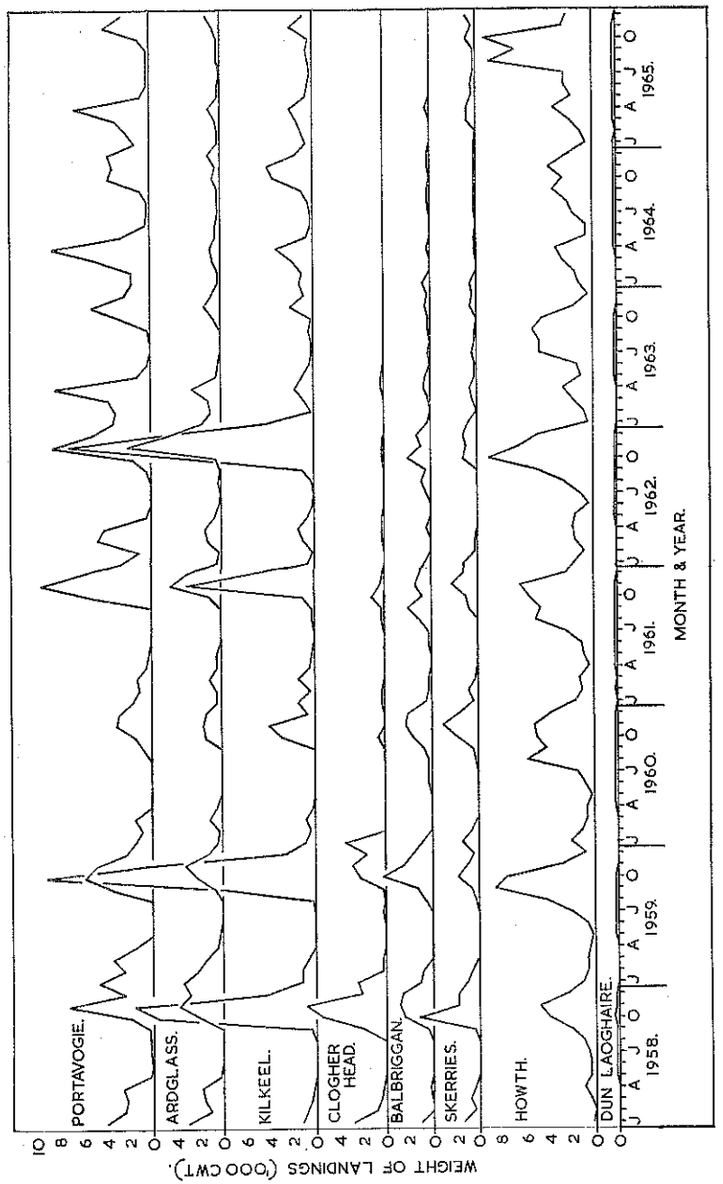

Fig. 4. Fluctuations in the whiting catch at Counties Dublin/Louth and Down ports ('000 cwt.), 1958/65.

Fig. 4 shows the great predominance of landings at Kilkeel during the years of very high autumn landings, of which the last was 1962. Other notable trends are the virtual cessation of landings at Clogherhead and the great decline at Skerries, Balbriggan, and to some extent Ardglass. The spring peak shows a gradual increase from 1958 to 1965, and from the most southerly to the most northerly ports. Thus, at Howth, where this peak was barely discernible prior to 1962, it was quite pronounced in 1965; at Portavogie, it has been a characteristic

throughout the period, and from being small but perceptible in 1958, had become by 1965 the greatest part of the fishery.

Fishing power. Magnitude, type and application.

Since the beginning of 1961, monthly returns are available of the average number of boats fishing from each port, classified according to their method of fishing (trawling or seining) and overall length. The length categories of these are shown in Table 4. Brake Horse Power (B.H.P.) was chosen as the most suitable unit of effort, and mean B.H.P. for each length category was calculated as far as possible, to the nearest 10 B.H.P. The mean B.H.P. for the small number of boats at Clogherhead will be seen to differ slightly from that elsewhere.

Changes in the gross B.H.P. present at each east coast port during 1961/62 are shown in Fig. 5, from which it will be seen that (except at Skerries) there was a decrease in numbers of boats of under 55 ft. overall length and a slight increase in boats of the larger categories, which are virtually confined to Howth and Dún Laoghaire. Fluctuation in the number of boats present was more marked at Howth and Dún Laoghaire than at the small ports further north, and more marked amongst the boats of 55 ft. and over than those of under 55 ft. Amongst the larger boats at Howth a great reduction in numbers during November/January each winter was due to the departure of many to participate in the Dunmore East herring fishery.

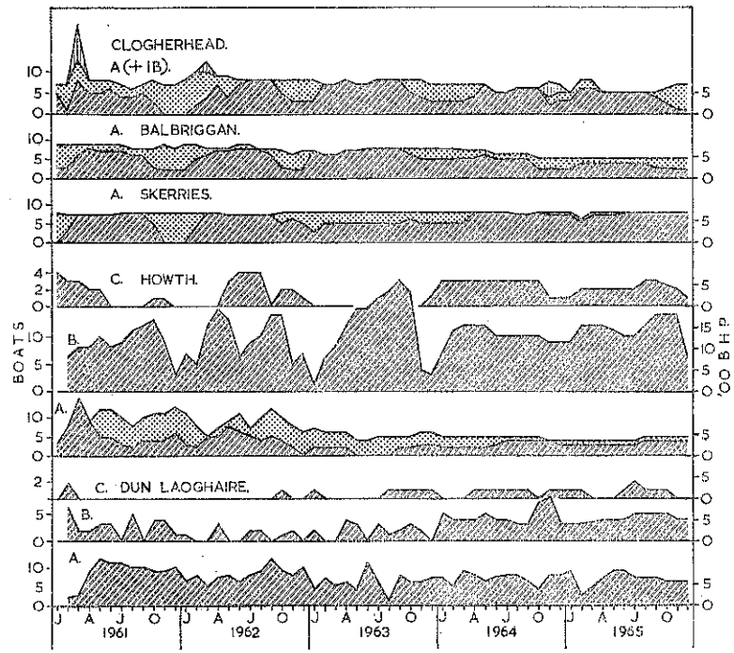

Fig. 5. Amount of fishing power based on east coast whiting ports, 1961/65 by length categories of boat (see Table 4). Type of effort indicated thus: trawling, diagonal lines; seining, spots; occasional visitors (at Clogherhead), vertical lines.

Seining was confined (with one occasional exception at Clogherhead) to boats in the smallest category and was used seasonally, many boats being adapted to this method of fishing for the whiting season during the autumn and thereafter resuming trawling. Since 1961, however, owing to among other things the high cost of gear, the amount of seining has declined sharply, and at Clogherhead and Balbriggan where it has to some extent persisted, it is now used mainly to catch cod or plaice.

The east coast whiting grounds support a mixed fishery and the relative importance (by value) of each of the main species during 1961/65 is indicated in Table 5. At Howth, where whiting were in all years the most important species, cod and plaice were also landed in quantity. Skerries had a large *Nephrops* fishery and contributed some whiting, but less of other demersal fish. At Balbriggan, the total value of landings fell considerably, and those of whiting fell most sharply. Clogherhead landings of whiting have been very small, the effort being applied mainly to plaice, *Nephrops* and recently sprat. Landings at Dún Laoghaire included a small amount of whiting in a wide variety of demersal species, of which plaice was the most important.

Assessment of unit effort.

The catch per unit effort is the most widely used index of abundance, effort being the product of fishing power (Fig. 5) and fishing time. Both these factors are given in the monthly returns commencing with 1961, the data being *number of boats fishing* in each category, during the month and *number of days fished* in each week. The amount of time of application of fishing effort necessarily varies according to size of boat, small boats being more easily deterred by bad weather than large. In the case of tidal ports there is also the necessity for suitable weather to coincide with the right tide to permit exit from the port, boats being unable to benefit from improved weather once the ebb tide leaves them aground. The complete harbour dries for substantial periods at Skerries and Balbriggan, and much of the accommodation does so at Clogherhead.

Variations in Catch per Unit effort.

Owing to the fact that Howth was the only port to have substantial landings of whiting throughout the period from 1961 to 1965, values for the catch (Fig. 6) are shown for the whole Dublin/Louth fishery and for Howth separately but effort and catch per unit effort are shown for Howth only.

There is a large autumn peak in the catch and one in spring scarcely perceptible in 1961, but progressively more important in succeeding years. Regarding the main autumn season, 1961 is seen to be a good year, 1962 very good, 1963 and 1964 poor and 1965 fair. A sharp fall is noticeable in December/January of most winters and another in May/June, the latter however being slight in 1963 and 1965. The decrease of whiting landings at ports other than Howth became striking

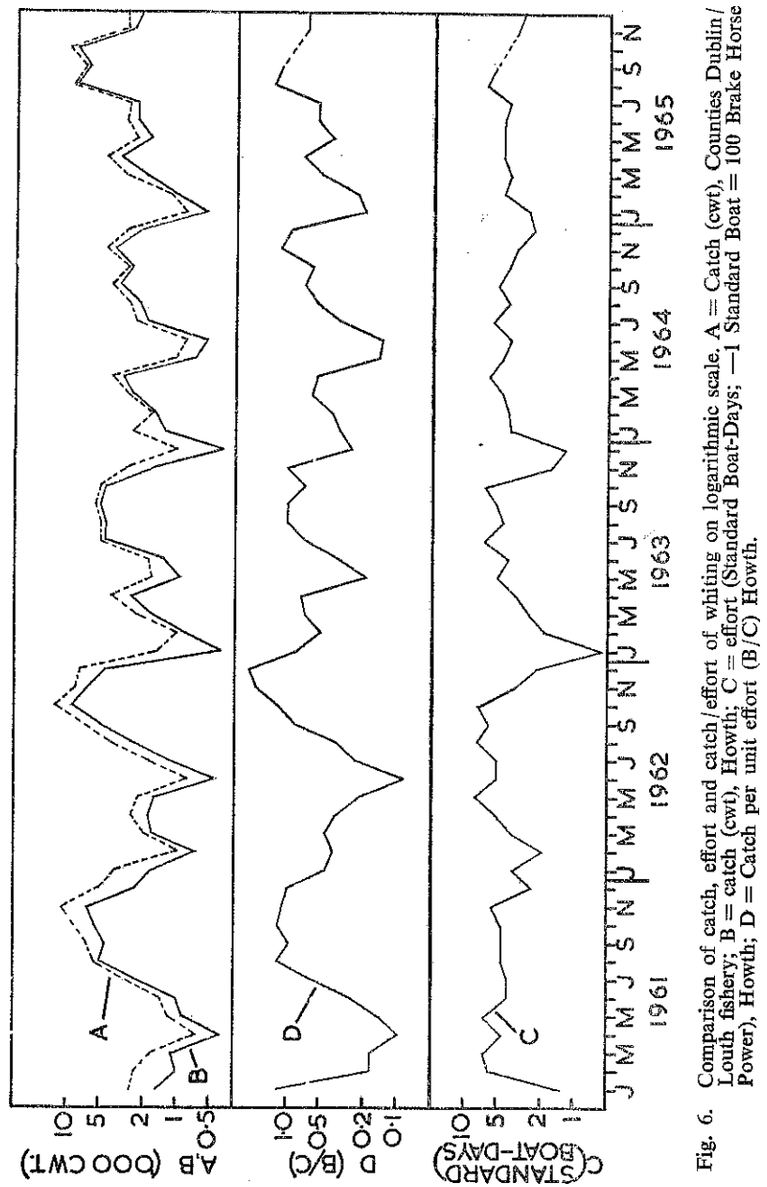

Fig. 6. Comparison of catch, effort and catch/effort of whiting on logarithmic scale. A = Catch (cwt), Counties Dublin/Louth fishery; B = catch (cwt), Howth; C = effort (Standard Boat-Days; —1 Standard Boat = 100 Brake Horse Power), Howth; D = Catch per unit effort (B/C) Howth.

in 1964 and 1965 when Howth landings closely approached the total landings for the area, especially during the autumn season.

Regarding effort, the chief source of fluctuation, as already mentioned, is the winter absence of boats fishing for herrings at Dunmore East. Hence the mid-winter fall in catch per unit effort is much less than the fall in catch. The annual cycle of abundance is thus seen to

consist of a strong dip in May/June (except in 1965) climbing steadily to a peak in the September/December period, followed by a subsidiary trough in January/February and peak in March/April. The level of effort, apart from the winter trough was about 50 boat days per month in 1961 and 1963, slightly higher in 1962 and, after the low catch in 1963, slightly lower in 1964 and 1965. Being on the whole consistent, however, it does not render the form of catch/effort graph very different from that for the catch, except during the Dunmore East herring season.

COMPOSITION OF THE LANDED CATCH

The catch of whiting by trawl or seine is made almost exclusively on one-day trips, the crew sorting the catch at sea, rejecting undersized whiting and sorting the remainder by size into two (or very rarely, three) categories. Usually large whiting, but not small, are gutted.

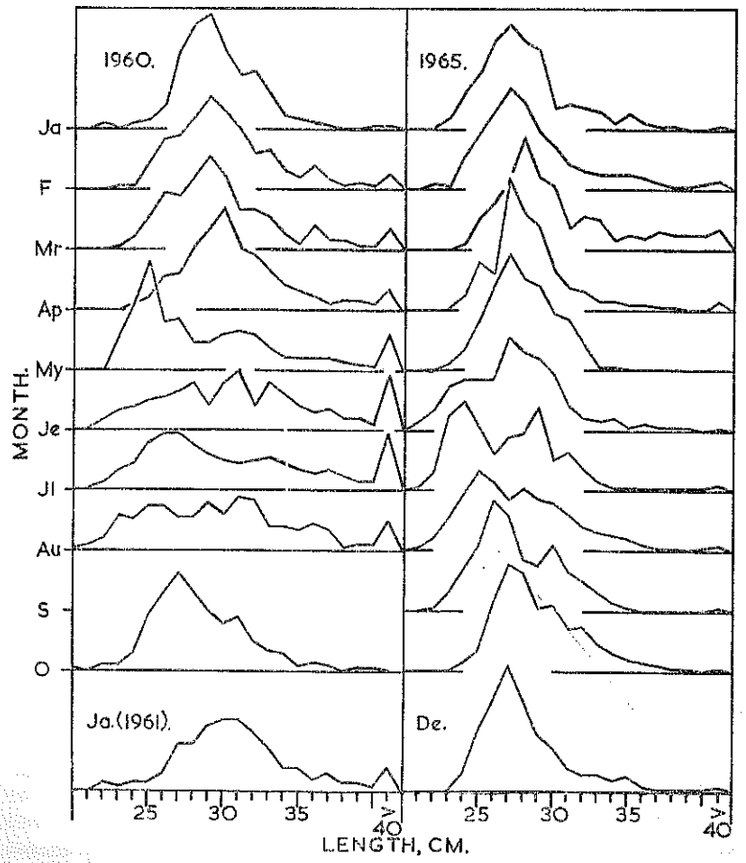

Fig. 7. Percentage length-frequency distribution of whiting in the commercial catch by months, January 1960—January, 1961, and 1965. The distance between consecutive monthly baselines represents 10%.

Stratified samples consisting of one box of each category were selected at the port or in Dublin market and examined in Fisheries Laboratory the following day. Ages were determined by otolith readings made by transmitted light, as described by Gambell and Messtorff (1964).

Length composition.

The length composition of the landed catch showed a mode at 26/28 cm (29 cm in 1960) during the peak season of September/December (Fig. 7) corresponding closely with Garrod and Gambell's findings for Co. Down. It emphasises that the fishery is mainly based on a single year class, no older class showing any definite or consistent peak. The distribution is bimodal only in some years during the summer when caches are low during the process of change in the predominant year class as that in age-group 2 is being replaced by its successor in age-group 1. In addition to very small fish, in the course of recruitment, the summer landings frequently exhibit an increased percentage of very large fish. These apparently emigrate at spawning time to a lesser extent than the young adults (group 1, rising 2) and are more liable to capture on their deep grounds as fishing effort is less concentrated on the main whiting grounds, in shallower areas.

The two years show rather different situations during summer. In 1960 there was a very low catch (Table 3) with poor development of modes in age-groups 1 and 2 and large fish relatively prominent, whereas in 1965, when the catch remained higher, the twin modes of age-groups 1 and 2 were outstanding, but very large fish relatively few.

Age composition.

Percentage age compositions of the catch are shown in Fig. 8. These are based mainly on commercial material augmented in some cases by research vessel data. Age-group 1 fish predominate in the autumn peak season of the fishery, varying from about 70% by numbers in 1963 to over 90% in 1962 and 97% in 1961. The corresponding percentages by weight are about 60% (1963), 85% (1962) and 95% (1961). The changeover in dominance during the summer also shows clearly. In the summer of most years there was a slightly increased percentage in fish of age-groups 3 and above. This trend is naturally more clearly seen with weights as numbers of these fish are very small. The maximum age of occurrence in samples is also best seen with weights, age-group 4 usually being represented and older age-groups irregularly so, in decreasing numbers, up to age-group 9.

A slight variation in age composition appears to exist between trawl and seine catches, the seine catches having a higher percentage of the younger age-groups (Table 6). The reason for this would appear to be the greater specialisation of the seine to fishing heavy concentrations of fish and its more strict confinement to relatively shallow water, both of which features, as already mentioned, tend to be associated with a youthful age composition.

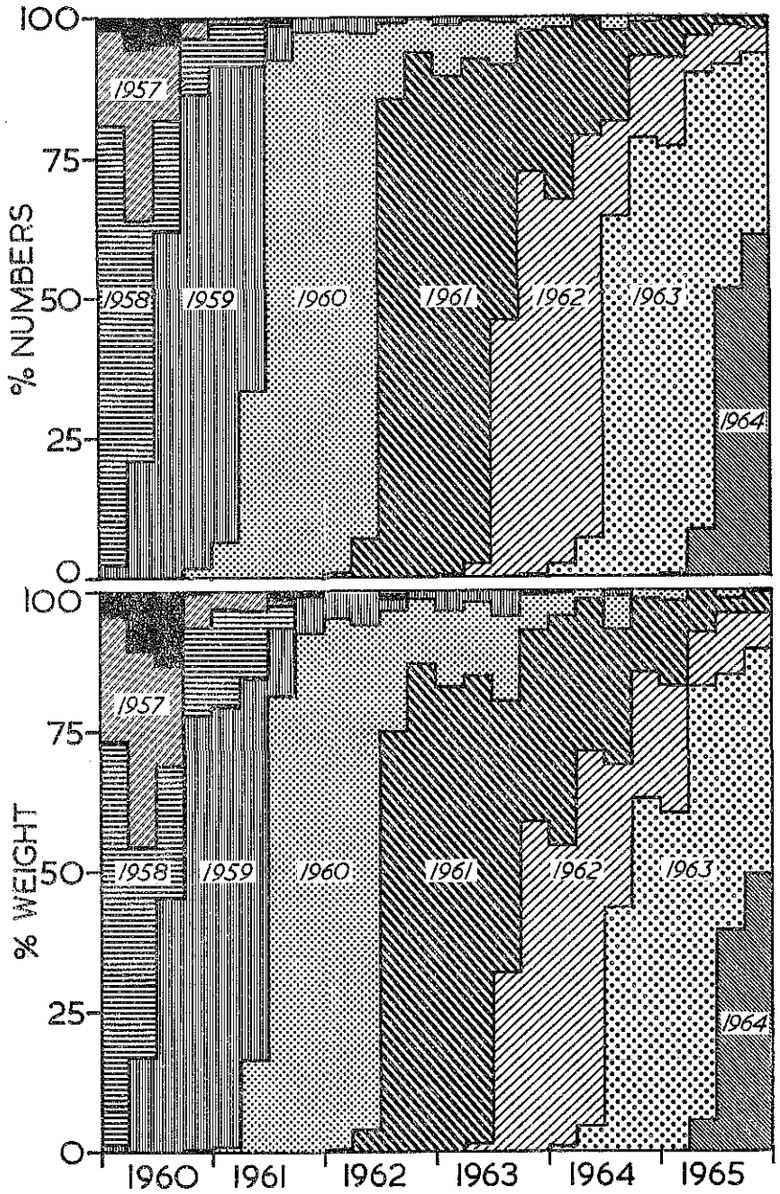

Fig. 8. Age-composition of the whiting catch in the Counties Dublin/Louth fishery quarterly, 1960/65, A by numbers and B by weights. Year classes, except for 1956 and earlier (shown in black) indicated in italics.

Factors governing recruitment.

The minimum legal mesh for Whiting fishing is the fishery is 60 mm. Hillis (1962a) obtained values of 3.4 and 3.5 for the selection factor

with cod-ends of (nominal) 50 and 60 mm mesh, but recent more detailed experiments have given a figure of 3.8, with a courlene vinge trawl and small meshed cod-end cover (Table 6). This is slightly higher than that of 3.7 adopted in the *Report of the Ad Hoc Committee of the Permanent Commission* (1956) which however showed considerable variation to exist, and was based on cod-ends of natural fibres. Artificial fibre cod-ends have been shown to give a slightly higher selection factor (Pope, Roessingh and von Brandt, 1958).

The selection curves for meshes of 50, 60 and 70 mm are shown in Fig. 9, together with a curve based on comparisons of commercial landings with research vessel catches using a small-meshed cod-end to show the percentage of the stock recruited by manual selection by the crews for marketing. The Irish legal size limit for landing whiting is also shown, as well as the mean percentage of fish in the catch sorted into the "large" category.

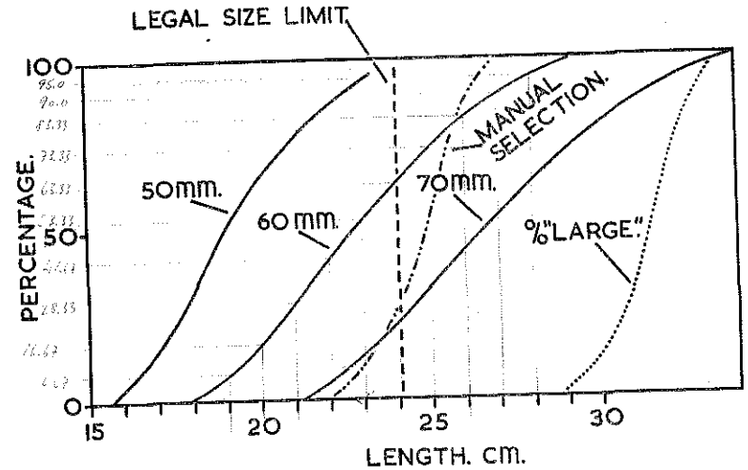

Fig. 9. Selection curves for Irish Sea Whiting.

The minimum length at which whiting may legally be landed, 24.1 cm (9½ inches), is 1.3 cm above the 50% retention point for a 60 mm cod-end and 2.5 cm below that for one of 70 mm. The manual selection applied to catches at sea in general keeps fairly close to the legal limit. Sorting is to some extent influenced by market demand, the size acceptable for marketing tending to rise when the supply is good, and to adhere closely to the legal minimum in times of scarcity.

The available information shows that age-group 1 fish of mean length are 50% recruited to 50 mm, 60 mm and 70 mm meshes in May, August and January, respecively, 50% recruited for the Irish minimum legal size in September, and this year class is in practice 50% recruited for landing in October. The late summer and early autumn are consequently a difficult time for sorting, as the mean length of the numerous recruiting year class is close to the legal size-limit.

Sorting is at its easiest during April/June, when age-group 2 is virtually entirely marketable, and practically none of age-group 1 is, making borderline cases very few.

GROWTH CHARACTERISTICS

Length

The available data from commercial and research vessel material are plotted in Fig. 13, and the von Bertalanffy growth curve derived from the equation $L_t = L_{oo}\ (1\text{-}e^{-k(t-\bar{t}_o)})$ for the research vessel material is drawn through them. The observed mean lengths for each age group are summarised in Table 8.

From the observed points, the seasonal pattern in growth is well seen (Fig. 10), age-groups 0, 1, and 2 showing a marked winter check from about December to March in age-group 0, and December/April in age-groups 1 and 2 (2 and 3 respectively from April) when winter is succeeded directly by the spawning season. In age-groups 4 and 5 the mean length is seen to be highest in the summer, coinciding with the higher percentage of large fish in the catch. Material becomes ex-

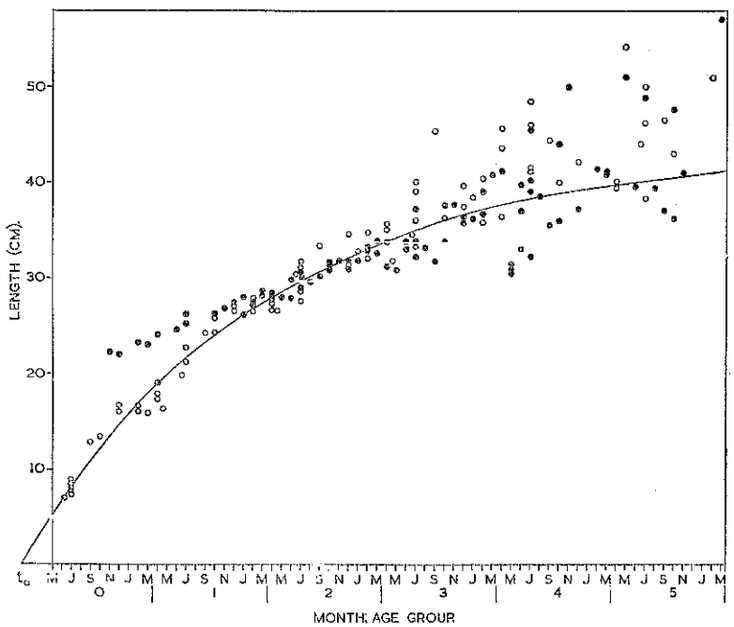

Fig. 10. Growth in length of whiting. Mean lengths for individual samples are plotted for commercial material (solid circles) and research vessel material (open circles). The ideal growth curve derived from research vessel material is shown by the solid line.

tremely scarce at about age-group 5, and the oldest fish examined were two of age-group 9 caught in July, 1964, one of which was the longest (66 cm) and heaviest (2,798 g) recorded.

The ideal curve fits the plotted observations well for age-groups 1 to 3 or 4, but at higher ages where data are too scanty and irregular for use in calculating the growth curve, the observed lengths tend to be greater than the theoretical. That is to say, in the plotting of lengths for pairs of successive years (l_{t+1}/l_t) the slope of the line, k, becomes steeper at old ages. This trend is to some extent due to both growth-rate and longevity in female fish being greater than in males, but by the time the divergence of observed and calculated data becomes perceptible, in age groups 4/5, numbers have dropped to a very small fraction of the population.

As has been shown (Gamble, Roessingh & Sahrhage 1961, Gambell & Sahrhage 1962, Gambell *et al* 1962, Hillis 1962b and 1963, and Hannerz 1964), local variation in the growth rate of whiting can be considerable and in this case the research vessel material is preferable to the commercial because it includes the pre-recruits and it covers all depths at which whiting occur on the fishing grounds, rather than concentrating on those of maximum density. The research vessel material provides the following values for the parameters of the von Bertalanffy growth equation:—

L_{oo}	K	$\bar{t}_o$
43.68 cm.	0.476	—0.193 years.

Values of L_{oo} are compared with those of populations elsewhere in Table 9, the value in the present material being very slightly higher than that off Co. Down though the growth rate through most of life is markedly higher (Garrod 1967, pers. com.). The west of Scotland and northern North Sea growth rates are similar to that of the Irish Sea. The North Sea growth rates vary, however, from this level in the north down to the lowest for any whiting stocks in the south-east. The L_{oo} for south east of the Dogger Bank is calculated from recent data of Sahrhage (1965). The higher growth-rates, in ascending order, are those of the West of Ireland, the Clyde, and Iceland, which is very much higher than any other.

Weight.

The mean monthly gutted weights of commercial and research material are plotted in Fig. 11. The larger closed and open circles to which the graphs are fitted indicate the moving averages over periods of a year, plotted twice yearly. The values for commercial material are higher than those for the research vessel material in the case of young fish, due to partial recruitment in the former, and lower for very old fish due to youthful age composition in areas of high stock density and fishing intensity previously mentioned.

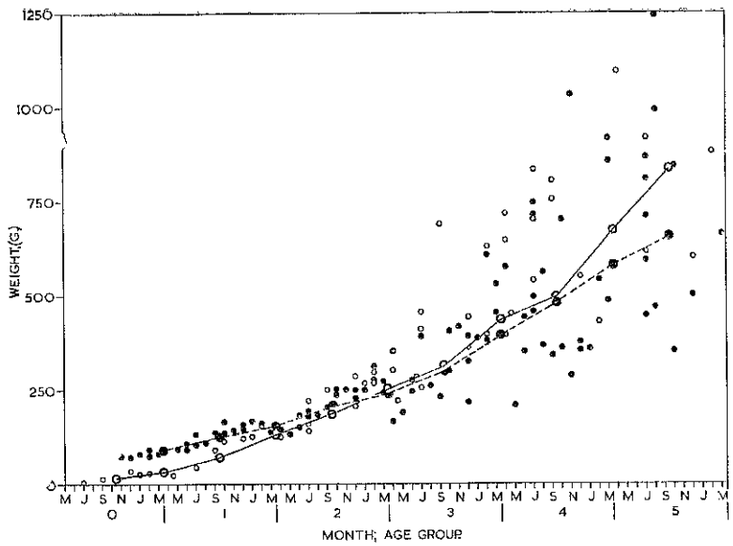

Fig. 11. Growth in weight of whiting. Commercial data shown in solid circles and dashed line; research vessel data in open circles and solid line.

The logarithmic means of the gutted weight for fish in each age group are shown in Table 8, logarithmic means being chosen in preference to the arithmetical as giving a truer measure of the mean value where it is small relative to the range in values and there is a tendency for the distribution curve to have a strong positive skew. This table demonstrates the unreliability of mean weights at age-groups 6 and higher, where material is scarce. In age-group 6 for example, the mean includes the weights of three abnormally small specimens of the same year class, 1959, caught within three months of each other in late 1965. With very old fish, observations are too few to permit a reliable estimate of the asymptotic weight W_{oo}; this lack of material is a strong indication of the youthful nature of the stock in the fishery.

Condition.

The condition factor (k) of a fish is calculated from the formula $k=100g/l^3$, where g is the gutted weight in grammes and l is the length in cm. Values of k for commercial material (1963/65) are shown in Fig. 12, which illustrates the seasonal rythmic change from lowest values in May, just after spawning, to highest in January, two to three months before next spawning. Also to be seen is the gradual overall increase in the value of k with age and size. Messtorff (1959) and Gambell (1963) and Garrod and Gambell (1965) have drawn attention to the increase in k with increasing size of fish, but it was noticed in the course of the present work that where two fish of equal length and different ages were compared, the older one would usually be the heavier, the slow-growing fish having a higher value of k than the fast grower. Some data on this phenomenon has been collected, and Fig. 13 shows the dfferent values of k at different ages for fish of mean

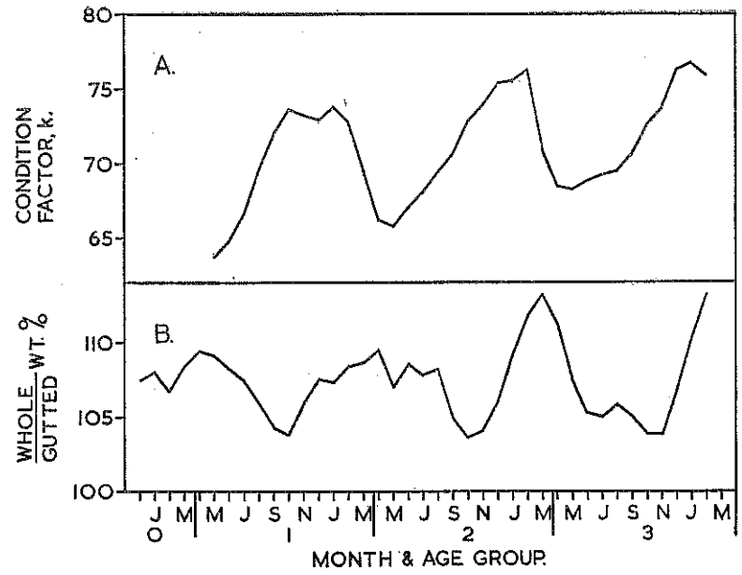

Fig. 12. Fluctuations (in moving means for three months) in A, condition facotr (k) and B, whole weight/gutted weight.

(gutted) weight, and of weights 25% above and below the mean value for a commercial sample of November 1959. In fish at age-group 1, k varies in direct proportion to weight, in all cases k increases from age 1 to 2, the amount of the increase being inversely proportionate to its previous value, and from age-groups 2 to 4 there appears to a slight decrease for the fast-growing fish, a slight increase for the fish of mean weight, and an increase which remains large, though progressively lessening, for the slow-growing fish.

Closely related to condition is the ratio of "round" or whole weight (W_r) to gutted weight (W_g) Fig. 12 shows the rhythmical variations in weight of viscera, which is highest in March/April and lowest in October/November. The main cycle coincides closely with the state of the gonads which are well developed in mid-winter, full and ready to run in March, when the ovaries for a short period are much swollen by the enlargement of ova in the transparent stage, and ready to be shed. In June, the gonads are empty, but some resorption has still to take place before the developmental part of the cycle recommences in autumn. The overall impression is of a developing season from October to March, followed by spawning, and a resting season from May to October.

Except for a minority amongst the larger males, whiting do not spawn at the end of their first year, hence the value of W_r/W_g continues to increase until May, the peak value being later and lower than with older fish, and being finally reduced to resorption of gametes. The maximum pre-spawning value of W_r/W_g increases with age from about 110 at 0 to over 115 at 3, but its general value outside the spawning season decreases in the same period from about 108 to 105.

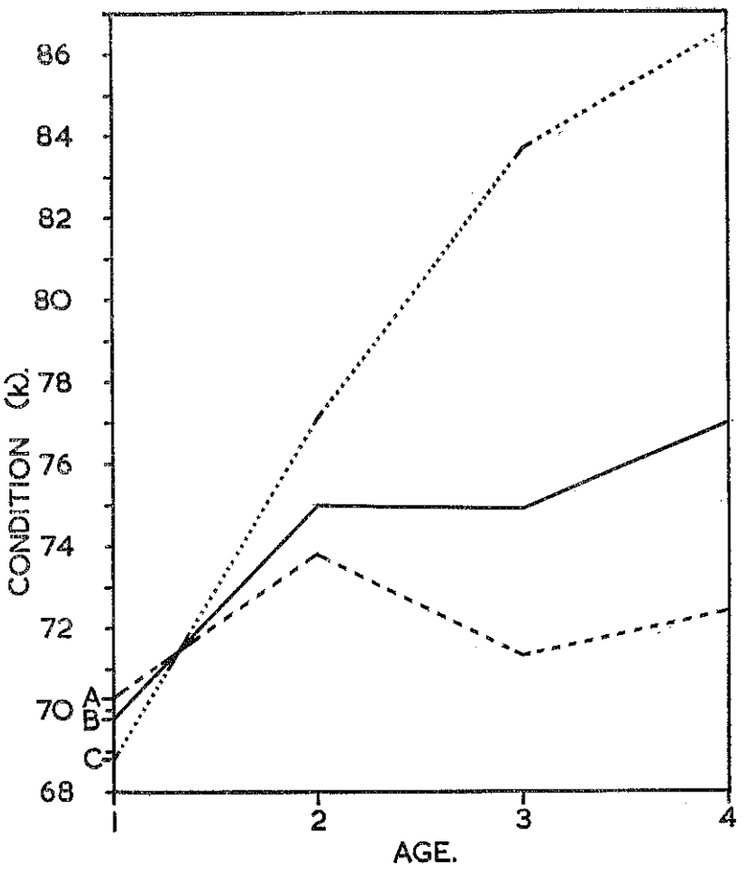

Fig. 13. Variation of condition factor (k) with age for fish of weight 25% above the mean (broken line), fish of mean weight (solid line), and fish of weight 25% below the mean (dotted line).

GROSS PRODUCTION AND MORTALITY

Weight.

Applying the percentage age-composition of the commercial catch, (Fig. 9) to the amount of whiting landed, the weight and numbers of each year class caught during each month were calculated, giving the relative strength of each year class, and its gross product during its lifetime. The cumulative weights are shown in Fig. 14 in which, up to the end of 1965, year-classes 1959 and 1960 have virtually completed their production, and 1961 nearly so. By December, 1965, the poor 1962 year class was at age-group 3 and that of 1963 at 2, both thus with some contribution still to come. The important autumn season at age-group 1, however, may be compared for all five year classes, the steepness of the graph denoting the size of the catch. In December at age-group 1, when the peak of their first season was past, year classes 1959, 1960 and 1961 had yielded roughly 30,000 cwt. and the 1962,

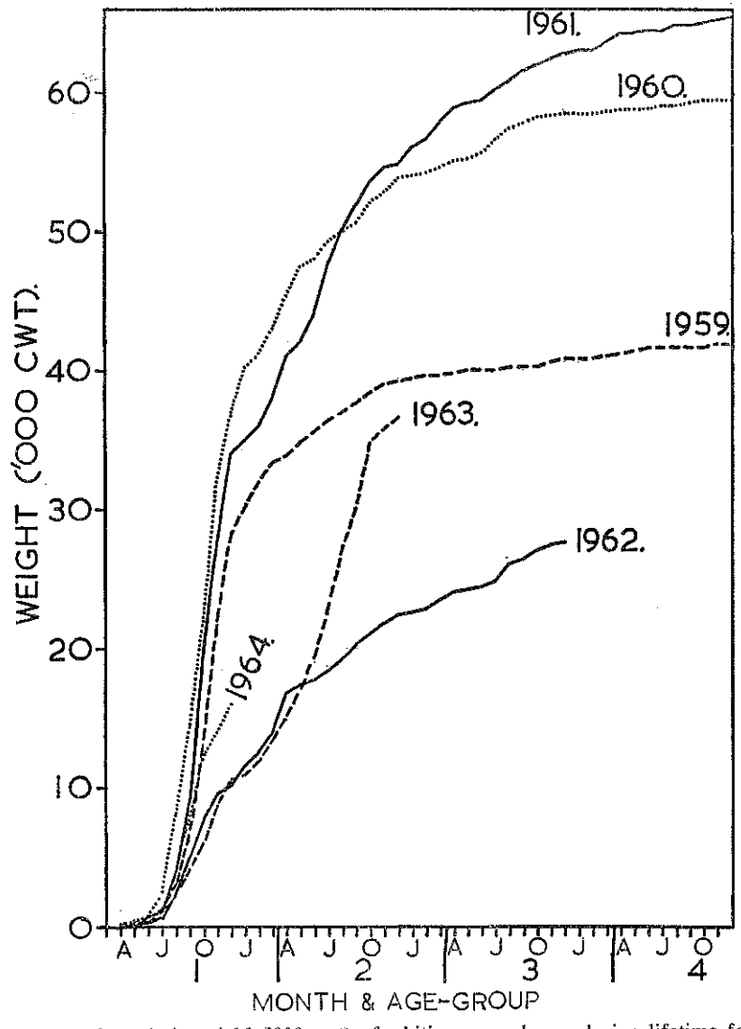

Fig. 14. Cumulative yield ('000 cwt) of whiting year classes during lifetime for Counties Dublin/Louth fishery.

1963 and 1964 classes well under 20,000 cwt. The yield of the 1962 and 1963 year-classes remained very similar up to April at age-group 2, including an increase during early spring (which also occurred to a fair extent in the 1961 class), but thereafter the 1963 class far outstripped the 1962. The development of the spring peak centred about March is also seen in Fig. 14.

There is an obvious trend for an increasing percentage of each age-group to be caught at a progressively higher age as the period of observation proceeds. Table 10 demonstrates that, though the sharp change occurred between year classes 1961 and 1962, nonetheless the trend has been continuous. The cumulative yield of the 1961 year

class overhauls that of the 1960 in August at age-group 2, while in December at age-group 2 that of the 1963 year-class is closely approaching that of 1960. Subsequent to December in age-group 4 the yield is very small, 33 and 31 cwt. respectively in the following two years with the year class of 1959, and 393 cwt in the following year with that of 1960.

By employing the most recent factors of percentage increase shown in Table 10, estimates are obtained for the gross production by December at age 4 of the 1962 and 1963 year classes, which indicate to some extent the relative potential yield of each year-class.

The chief trend between 1960 and 1965 may be summed up as a reduction in the quantity of age-group 1 whiting in the catch, and an increase in the quantity of whiting of age-groups 2 and older, giving a reduced total catch with a larger mean size of fish. This would appear to result from a reduction in fishing effort for whiting, which has certainly taken place, partly in the form of a reduction in seining effort, which had tended to yield small whiting in large quantities. The intense cold of early 1963 may also have reduced the numbers of the previously numerous 1962 year class so that in autumn 1963 they failed to support the customary fishery for age-group 1 whiting and interest in pursuing this fishery had not by 1965 returned to its former level.

Numbers.

In the case of numbers, the cumulative yield curve is of similar appearance, but the superiority of the younger age-groups shows up more markedly. The numerical yield is used in conjunction with the values for effort already calculated for Howth, to give an assessment of catch per unit effort, which is given in Table 11 in numbers per 100 B.H.P. days (= 1 day's fishing by fairly small boats,—see Table 3). From this, estimates of total mortality, Z, are obtained (Fig. 15 and Table 12). The values quoted in Table 11 are arithmetical; those in Fig. 15 and Table 12 are the basis of the $\log_e$.

The abundance of whiting is given in Table 11 quarterly for each year class, in age-groups 0/5. The year during which any given abundance occurs is found by adding the age-group number to that of the year-class year, except during the first quarter, when owing to the convention of changing the year class at the end of March, a further 1 year must be added. In discussing abundance year-classes are quoted rather than years.

From their first appearance in the fourth quarter in age-group O, whiting increase slowly in abundance until the second quarter of the following year (age-group 1), having their strongest increase from the second to the third quarters, and a lesser one from the third to the fourth, where numbers in the commercial catch are at their lifetime peak. The order of magnitude of year classes is: 1961 which reached over 5,000 fish per 100 B.H.P. days; 1960, which exceeded 3,000

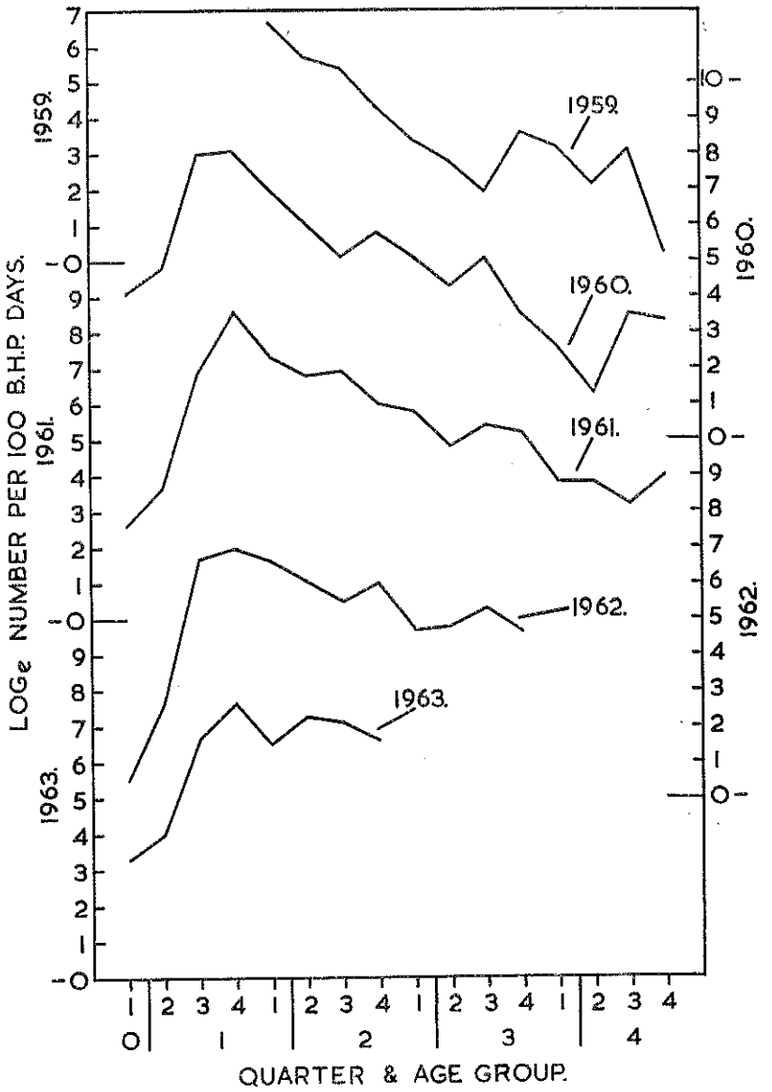

Fig. 15. Total mortality coefficient, Z. Changes with age in $\log_e$ of the number of whiting of each year-class in the commercial catch (per 100 B.H.P. days) at quarterly intervals.

(having had nearly 3,000 the previous quarter); 1963 (2,300), 1964 (1,800) and 1962 (1,100). After the fourth quarter, numbers in age-group 1 fall off, more rapidly in the earlier year classes, and with a tendency to recover in the third or fourth quarter of subsequent years (Table 11), so that in the fourth quarter, the main whiting season, age-group 2 fish number from 70 in the 1959 year class to 700 in that of 1953, age-group 3 fish from 0.6 (1958) to about 170 (1961) and age-

group 4 from complete absence to 56 in the two year classes. The peak quarter, however, has swung from the fourth quarter to the third (except for fish of age-groups 3 in 1959 and 4 in 1961) and this trend is continued in age-group 5.

Fig. 15 shows the increased mortality rate during the season of the peak fishery for age-group 1 fish. This is especially marked in the 1961 year-class and the value of Z between the 4th and 1st quarters for the four year-classes examined is of the order of 5, except for that of 1962, where it was under 2. Except for this year-class, these are much higher than any values over a yearly period. With the 1963 class, however, the weather during much of the first quarter at age-group 1 was poor enough to depress the catch, which recovered substantially in the second quarter (now aged 2). Mortality normally slackens as the year-class passes into age-group 2, and the line assumes a more constant slope, steep in the earlier year-classes, gentler in the more recent, tending to become irregular in age-group 3, due to scarcity of fish, and increasingly so thereafter.

Table 12 gives values of Z over periods of a year, quarterly, commencing with the first appearance of the young fish in the fishery in the fourth quarter at age-group 0. For yearly periods commencing with the quarters during and immediately succeeding the main fishery (4th and 1st at age-group 1; 2nd at age-group 2) the mean value of Z is 1.96 which agrees closely with that of Garrod and Gambell, 1.9 for Co. Down material. There follows a period (from 3rd quarter, age-group 2 to the 4th quarter, age-group 4) when it rises from 1.3 to about 1.7, with a mean of 1.50, slightly higher than the 1.4 of Garrod and Gambell. Thereafter, scarcity of fish makes values of Z very high and irregular.

SUMMARY

The whiting fishery off Co. Dublin on the east coast of Ireland has been described. Its place amongst other fisheries is discussed, and it is shown to be with that off Co. Down, the chief whiting fishery both of Ireland and of the Irish Sea. It is to a considerable extent continuous and interchangeable with the County Down fishery and these fisheries (but more especially the Dublin one) bear a strong resemblance to that in the Firth of Clyde, which like them has a pronounced autumn peak, and is mainly composed of age-group 1 fish.

The total catch for the whole County Dublin fishery and for Howth has been shown since 1961, its good seasons being 1961 and 1962, and poor ones 1963 and 1964. Seasonal fluctuations occur, the catch being high in autumn, and latterly in March,—and very low about June. Data concerning the vessels engaged in the fishery and time spent fishing were used to give an estimate of effort. The index of abundance, catch per unit effort, fluctuates less than the absolute catch, and the 1964 season, though lowest in its total absolute catch, in view of the small effort expended is shown to exceed 1963 in its index of abundance for Howth.

The length and age-composition of the catch demonstrates its dependence on age-group 1 fish, (group 2 after April), until they are replaced by the succeeding age-group 1 during June/September. The causative factors, principally the cod-end mesh, and manner of recruitment, are also discussed. During the summer months, with recruitment in progress, the length distribution is sometimes bimodal, but at other seasons it is unimodal with the mode at 25/28 cm (29 cm in autumn 1959) and a strong positive skew, due to the presence of the older age-groups. Variations in age-composition between trawl and seine catches are also mentioned.

Growth in length and age were examined, together with variations in the condition factor (k) with season and age. Owing to the prevailing practice of marketing the catch partly gutted and partly whole the relationship of whole to gutted weight was also examined. Growth by length was compared with that prevailing elsewhere as data are available for a number of different populations.

Gross productivity was calculated through analysis of the total landings by age composition, by weights and numbers. Gross productivity by weights was shown cumulatively for year-classes, indicating the comparative size of the contribution of each to the County Dublin Fishery during its lifetime. Gross numbers caught were based on fishing effort to give the catch per unit of effort for each year-class, from which the coefficient of total mortality, Z, was calculated. This agreed closely with other published material for the Irish Sea.

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Table 1. Catch and Index of Abundance (Irish Sea) and Catch, (Clyde) 1927/55.

Year	IRISH SEA CATCH ('000 cwt) Ireland Dublin /Louth	Ireland Down	Ireland Total	England & Wales	France(F)& Belgium(B)	Total	CATCH/EFFORT (cwt/boat/yr) Ireland	CLYDE CATCH ('000cwt) Scotland
1927	12	3	15	28	—	43	206	9
1928	11	2	13	24	12F	49	141	7
1929	10	3	13	22	—	35	149	5
1930	11	3	14	28	—	42	199	4
1931	11	4	15	27	—	42	195	4
1932	10	4	14	22	—	36	205	4
1933	10	5	15	23	—	38	213	4
1934	16	5	21	29	—	50	350	13
1935	19	9	28	27	1F	56	341	6
1936	15	17	32	30	3F	65	266	6
1937	13	7	20	22	1F	43	249	11
1938	17	17	34	50	7F	91	306	28
1939	16	15	31	—	—	31	298	21
1940	19	30	49	—	—	49	383	49
1941	21	34	55	—	—	55	472	48
1942	32	55	87	—	—	87	630	89
1943	23	31	54	—	—	54	459	55
1944	39	65	104	—	—	104	752	48
1945	55	106	161	—	—	161	1,074	41
1946	46	130	176	40	—	216	843	63
1947	29	132	161	84	—	245	457	70
1948	32	120	152	128	—	280	496	38
1949	31	67	98	171	—	269	443	51
1950	21	33	54	83	1F	138	280	58
1951	17	36	53	75	—	128	222	36
1952	16	44	60	71	—	131	204	31
1953	19	36	55	72	?F	127*	232	43
1954	37	59	96	86	+F	192	473	44
1955	32	70	102	69	1B	172	385	83

* Excluding French Catch.

Table 2. Catch and Indices of Abundance (Irish Sea) and Catch (Clyde), 1956/65.

Year	IRISH SEA CATCH ('000 cwt) Ireland Dublin /Louth	Ireland Down	Ireland Total	England & Wales	Irish (in Wales)	Scotland	France	Belgium	Total	CATCH/EFFORT Ireland (cwt/boat/yr)	CATCH/EFFORT England (cwt/100hrs)	CLYDE CATCH ('000cwt) Scotland
1956	40	48	88	60	—	—	9	+	157	573	17.2	24
1957	49	60	109	64	—	9	11	2	195	674	15.6	46
1958	70	76	146	56	—	2	34	3	241	933	23.7	71
1959	66	94	160	56	—	5	23	1	245	740	18.9	101
1960	55	28	83	75	4	+	42(16)*	+	204	621	45.9	41
1961	51	57	108	47	3	1	62(21)*	+	221	606	41.1	32
1962	53	95	148	77	—	2	72(20)*	1	300	657	67.2	40
1963	37	50	87	52	+	+	66(26)*	+	205	424	48.7	16
1964	32	53	85	26	—	1	150(21)†	3	265	438	22.3	53
1965	51	37	88	20	—	1	126(12)†	2	247	713	16.4	35

* Figures in brackets refer to landings at Boulogne-sur-Mer, estimated for Region VIIa, excluded from totals.

† Figures in brackets refer to landings at Boulogne-sur-Mer for region VIIa, supplied by l'Institut Scientifique et Technique des Peches Maritimes, included in totals.

Table 3. Monthly totals ('000 cwt) of whiting landed, Cos. Dublin/Louth and Down, 1958/65.

Mth.	Yr.	Howth	Dublin /Louth	Down	Total	Yr.	Howth	Dublin /Louth	Down	Total
J	1958	0.1	5.5	8.2	13.7	1962	1.7	3.7	3.6	7.3
F		0.05	1.3	4.2	5.4		0.7	0.9	1.4	2.4
M		0.4	1.2	4.1	5.3		1.7	2.1	7.0	9.1
A		1.0	1.6	4.5	6.1		1.8	2.6	6.9	9.6
M		0.5	0.7	0.4	1.1		1.6	2.2	1.5	3.7
J		0.5	0.8	0.1	0.9		0.4	0.8	0.5	1.3
J		0.7	0.9	0.2	1.1		1.2	1.8	0.08	1.9
A		1.0	1.4	0.2	1.5		2.7	3.9	0.3	4.3
S		2.0	4.9	0.6	5.5		5.0	5.9	1.4	7.3
O		4.0	17.3	17.6	34.9		9.0	12.6	12.4	25.0
N		4.8	16.6	26.6	43.3		6.4	8.7	37.2	45.9
D		2.3	9.1	9.4	18.5		4.7	7.4	22.3	29.7
J	1959	1.1	5.3	9.2	14.6	1963	0.4	1.5	8.9	10.4
F		0.7	2.4	5.7	8.1		0.9	1.0	3.9	4.9
M		0.6	00.9	5.3	6.2		1.7	2.4	5.3	7.8
A		0.4	0.6	2.1	2.7		2.5	4.0	12.3	16.3
M		0.2	0.4	0.3	0.7		0.9	1.7	2.6	4.3
J		0.6	0.9	0.02	0.9		1.3	1.8	0.6	2.4
J		1.9	2.3	0.02	2.3		4.6	5.2	0.4	5.6
A		4.5	5.2	0.2	5.4		4.5	5.0	0.3	5.3
S		8.6	11.0	11.7	22.7		5.1	5.6	0.5	6.1
O		7.5	16.0	30.9	47.0		4.3	4.8	3.3	8.0
N		2.7	8.9	22.6	31.5		1.6	2.9	8.4	11.3
D		0.8	4.5	6.0	10.6		0.4	1.0	3.8	4.8
J	1960	2.0	7.8	2.6	10.4	1964	1.3	2.6	3.0	5.6
F		1.0	1.7	1.5	3.2		1.6	1.7	2.9	4.6
M		0.7	0.8	3.2	4.1		2.6	2.8	7.1	9.9
A		0.7	1.0	0.5	1.5		3.3	4.0	12.6	16.5
M		0.3	0.5	0.1	0.6		0.7	1.1	2.3	3.4
J		0.8	1.3	0.08	1.4		0.6	0.8	1.0	1.8
J		1.3	1.8	0.02	1.8		1.9	2.4	0.6	3.0
A		5.9	6.5	0.1	6.6		2.3	2.7	0.7	3.5
S		4.2	5.4	0.6	5.9		3.4	3.9	1.9	5.8
O		5.0	9.1	5.7	14.8		2.5	2.9	7.7	10.6
N		5.2	10.5	8.5	19.0		3.8	4.3	7.5	11.8
D		3.9	7.8	4.9	12.7		2.2	2.7	6.1	8.8
J	1961	1.5	2.6	3.4	6.0	1965	0.5	0.8	2.0	2.8
F		1.0	2.4	1.7	4.1		1.1	1.2	3.3	4.5
M		1.1	1.7	3.7	5.4		2.0	2.9	5.0	7.9
A		0.4	0.6	0.8	1.4		3.4	4.7	9.3	14.0
M		0.9	1.2	0.5	1.7		1.8	2.4	1.5	3.9
J		1.0	1.4	0.1	1.5		2.4	3.0	0.6	3.6
J		2.4	2.9	0.1	3.1		2.4	2.8	0.4	3.2
A		5.0	6.4	0.5	6.9		8.7	9.2	0.9	10.1
S		4.5	7.5	0.4	7.9		6.6	7.0	1.0	8.1
O		5.5	8.3	7.1	15.3		9.3	10.2	1.6	11.9
N		6.5	10.7	24.9	35.6		2.5	3.1	6.7	9.7
D		2.5	5.1	14.3	19.4		2.1	3.1	4.4	7.5

Table 4. Mean Brake Horse Power (B.H.P.) of boats in different length categories 1961/66.

Length category (overall length, ft.)	Mean Brake Horse Power		Designation in Figure 6
	Clogherhead	Elsewhere	
43—54	100	90	A
55—65	114 (boat only)	130	B
over 65	—	200	C

Table 5. Values (£'000) of Landings of Whiting and other species of fish, 1961/65

Year	Whiting	Chief other Demersal: Plaice	Cod	Total Demersal	Pelagic	Nephrops	Total Wet Fish + Nephrops
Clogherhead							
1961	2.1	14.5	3.2	23.4	1.2	5.8	30.4
1962	1.5	11.6	3.8	19.1	+	12.2	31.3
1963	1.5	8.1	2.9	14.9	3.1	13.3	31.3
1964	0.4	11.1	2.4	15.6	11.1	5.8	32.6
1965	0.1	14.0	2.6	18.9	8.9	3.8	31.5
Balbriggan							
1961	9.2	9.0	6.5	27.5	0.2	5.0	32.7
1962	8.4	6.6	5.6	25.4	0.3	5.7	31.4
1963	4.6	5.8	2.6	14.3	0.8	8.6	23.7
1964	2.5	7.0	3.7	13.7	+	7.9	21.7
1965	1.6	8.7	2.9	13.4	+	7.7	21.1
Skerries							
1961	9.2	0.1	2.2	12.0	0.1	15.6	27.7
1962	4.7	0.2	2.4	8.0	—	24.1	32.1
1963	6.5	3.7	2.3	12.7	—	39.9	52.5
1964	4.2	2.9	4.9	17.0	0.4	20.3	37.6
1965	8.0	2.8	6.8	22.6	2.9	25.0	50.5
Howth							
1961	59.1	41.9	37.2	166.8	3.3	3.8	173.9
1962	58.5	41.5	40.0	168.9	1.2	3.9	174.0
1963	48.6	30.5	32.1	128.6	0.5	4.5	133.7
1964	49.9	50.8	41.4	166.1	0.8	3.9	170.8
1965	85.9	19.7	45.9	164.5	0.8	3.8	169.1
Dun Laoghaire							
1961	7.4	11.0	8.9	45.7	Pelagic } Nil		45.7
1962	2.8	10.1	4.8	35.1			35.1
1963	1.5	4.6	2.9	19.5			19.5
1964	2.2	10.7	4.9	37.1	Nephrops }		37.1
1965	1.8	8.3	5.2	32.3			32.3
Total Dublin/Louth							
1961	87.1	76.3	55.8	275.4	4.8	30.2	310.5
1962	75.9	69.8	56.5	256.4	1.6	46.0	304.0
1963	62.4	52.8	42.8	189.9	4.4	66.4	260.7
1964	59.2	82.5	59.2	249.5	12.3	37.9	299.7
1965	97.4	63.4	53.6	251.6	12.6	40.3	304.6

Table 6. Comparison of percentage age-compositions by numbers in pairs of landed catches made by trawler and seiner respectively during three months, 1965/66.

Age-group	February, 1965		September, 1965		May, 1966	
	Trawl	Seine	Trawl	Seine	Trawl	Seine
0	—	0.8	—	—	—	—
1	72.3	82.8	55.4	74.1	6.2	27.6
2	13.8	11.9	38.2	21.8	57.6	46.6
3	12.7	4.3	5.8	2.6	25.7	22.3
4	1.2	0.2	0.3	0.8	5.9	2.1
5	—	—	0.3	0.7	4.0	1.2
6	—	—	—	—	0.6	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 7. Selection factor for whiting determined by half hour hauls with small meshed cod-end cover, 1965 and 1967.

Date	Cod-end mesh (mm)	Haul	50% release point (cm)	Selection Factor
April 1965	45	1	17.1	3.80
		2	17.0	3.78
		3	16.7	3.74
		Mean	16.93	3.76
April /May 1967	53	1	18.7	3.53
		2	20.2	3.81
		3	20.4	3.85
		4	21.5	4.05
		Mean	20.2	3.81

Table 8. Mean lengths and weights of whiting in different age groups.

Age-group	Mean length (cm)	Logarithmic mean gutted weight (g)	Data
0	9.3	6	Moving average over periods of 1 year: research vessel data.
1	22.4	68	
2	29.8	185	
3	35.1	311	
4	40.4	433	
5	48.5	670	
6	41.2	474 (N=5)	Simple means: all available data 1959/65.
7	55.3	1,264 (N=3)	
8	59.0	1,226 (N=2)	
9	64.5	2,283 (N=2)	

Table 9. L_{oo} for Whiting from different areas.

Area	Authority	L_{oo} (cm)
South-western Iceland	**from** Saemundsson (1925)	67.4
Firth of Clyde	Gambell (1965)	54.5
West of Ireland	**from** Elkin (1955)	48.7
West of Scotland	Gambell (1965)	45.0
Northern North Sea	Ellis and Jones (1956)	44.2
Irish Sea (off Co. Dublin)	**Present work**	43.7
Irish Sea (off Co. Down)	Garrod (pers. com. 1967)	43.5
South-eastern North Sea	**from** Sahrhage (1965)	32.8

Table 10. Cumulative yield of year classes at 31st December, ('000 cwt.). Each yield is also shown as a percentage of that attained one year previously. Figures in brackets are extrapolations based on latest available percentages.

Age	%	1959	1960	1961	1962	1963	1964
1		28.2	36.8	33.9	10.2	10.5	16.1
	2/1	139	146	162	220	349	
2		39.3	53.9	54.9	22.4	36.6	
	3/2	103	108	115	123	(123)	
3		40.6	58.4	62.9	27.6	(45.1)	
	4/3	103	102	104	(104)	(104)	
4		41.8	59.4	65.4	(28.7)	(47.0)	

Table 11. Number of Fish in the Commercial catch at Howth by year-class and age-group at quarterly intervals. Units: Fish per 100 B.H.P. days.

Age-group	Quarter	YEAR CLASS 1958	1959	1960	1961	1962	1963	1964
0	4th					0.4	2.7	0.6
	1st			58.4	13.3	1.7	24.6	1.2
1	2nd			123.2	38.9	15.3	54.8	
	3rd			2,850.0	920.2	812.0	843.3	81.9
	4th			3,271.0	5.182.0	1,129.0	2,315.0	1,504.0
	1st		776.8	1,052.0	1,466.0	711.7	633.2	1,765.0
2	2nd		287.9	454.8	892.3	416.8	1,469.0	
	3rd		219.0	183.3	952.7	240.6	1,221.0	
	4th		72.4	328.7	394.3	422.6	701.8	
	1st	78.6	29.9	156.2	314.7	107.7		
3	2nd	36.7	16.5	72.2	127.5	119.7		
	3rd	36.4	6.7	162.2	225.6	208.6		
	4th	0.6	35.3	35.9	173.3	96.6		
	1st	—	25.0	13.1	44.1			
4	2nd	—	8.0	3.7	46.5			
	3rd	0.3	21.7	32.3	24.9			
	4th	—	1.1	27.2	56.3			
	1st	0.4	0.3	1.7				
5	2nd	—	0.2	0.3				
	3rd	—	0.3	11.9				
	4th	0.4	—	0.8				
	1st	0.1	—					

Table 12. Total Mortality coefficient, Z, measured quarterly over periods of 1 year derived from numbers of fish caught per unit effort Howth.

Interval between age-group	Calendar Quarters	YEAR CLASS								Overall mean for period shown
		1958	1959	1960	1961	1962	1963	1964	Mean	
0—1	4th					—7.92	—6.76	—8.07	—7.58	
,, ,,	1st			—2.89	—4.70	—6.07	—3.25		—4.23	
1—2	2nd			—1.31	—3.13	—3.30	—3.29		—2.76	
,, ,,	3rd			2.74	—0.03	1.22	—0.37		0.89	
,, ,,	4th			2.30	2.58	0.98	1.19		1.76	
,, ,,	1st		3.26	1.91	1.54	1.89			2.15	1.96
2—3	2nd		2.86	1.84	1.95	1.25			1.97	
,, ,,	3rd		3.49	0.12	1.44	1.14			1.30	
,, ,,	4th		0.72	2.22	0.83	1.47			1.31	
,, ,,	1st		0.18	2.48	1.96				1.54	1.50
3—4	2nd		0.73	2.68	1.01				1.47	
,, ,,	3rd	4.93	—1.17	1.61	1.58				1.74	
,, ,,	4th		3.50	0.28	1.11				1.63	
,, ,,	1st		4.36	1.07					2.72	
4—5	2nd		3.68	2.70					3.19	
,, ,,	3rd		4.13	1.00					2.57	3.00
,, ,,	4th			3.51					3.51	

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